Development of a Toolkit for the Wii MotionPlus: Calibration, Data Recording and Visualization

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ABSTRACT

With the advent of motion-based controllers, such as Nintendo's Wii remote, the online community has brought forth many libraries to connect such devices to a personal computer. In this paper we present a toolkit for the Wii MotionPlus, comprising of a calibration, a recording and a visualization tool. The purpose of the calibration tool is to calculate the parameters to correct the data from the accelerometer and gyros, such as bias and scale factors. With the recording tool data from the Wii MotionPlus are written in text format to a file for later analysis. Visualization of the data samples is handled by two human friendly, real time representations of those samples: oscilloscope-like graphs and a 3D representation of the Wiimote's orientation, calculated from the sensor data. These tools can help developers of future applications to interpret the sensor data, to gain insight in the possibilities and the limitations of the controller, and to find suitable algorithms to extract the information of interest.

Categories and Subject Descriptors

H.5.2 **[Information Interfaces and Presentation]**: User Interfaces---*input devices and strategies*

General Terms

Algorithms, Measurement, Experimentation

Keywords

Accelerometer, Calibration, Gyro sensor, Data recording, Visualization, Wii MotionPlus

1. INTRODUCTION

With the release of the Wii in December 2006, Nintendo has not only conquered a privileged spot in many households, it has also sprouted forth a true sandbox for developers to play in. Developers were always limited however by the inaccuracy of the Wii remote's sensors, especially the accelerometers. These sense all acceleration they experience, both due to movements induced by the user, as well as gravitation. In 2009, the Wii MotionPlus came out; Nintendo answered to its customers' pleads for more accuracy by releasing a dual- and single axis gyroscope, to be fitted at the bottom end of the Wiimote. As all sensors, their accuracy is limited, which can be partly compensated by proper calibration.

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Projects like the WiiYourself! library [1] on Windows or the CWiid library [2] on Linux considerably lowered the learning curve and time required for other developers' projects by taking the load of reading out Wiimote registers off their shoulders. The values resulting from both libraries however are not easily interpretable, user motions are not accurately tracked, even after an attempt towards calibration by using pre-defined calibration values available in the Wii controller's registers, nor are values from several types of sensors combined in order to aid each-other to better map the movements. On top of that, there is no tool yet available to record various output provided by the Wii remote (and Wii MotionPlus) and store for examination, and no software is available to convert those raw values into human-readable, easily usable values, calibrated and combined with other sensors' measurements for optimal accuracy, and visualize true one-to-one mapping. The Wii MotionPlus tool described in this paper fulfills all these needs .

2. CALIBRATION TOOL

The purpose of the calibration tool is to calculate the parameters that describe the relation between the digitized sensor output and the true observed acceleration and rotational speed of the Wiimote. These parameters include among others the bias, corresponding to the sensor's output when the real acceleration or rotational speed is zero, and the scaling factors which relate the sample values to the correct physical quantities. The calibration procedures are based on the methods proposed by Ferraris et al. [3]. These procedures are implemented in the proposed tool, and the calibration parameters are automatically calculated.

The user is first asked to put the Wiimote in six different positions, laying on each side, as displayed by an animation (see Figure 1). Afterwards, the user has to perform a full revolution around each of the axes of the Wii controller. By combining the measurements from each step, the calibration parameters can be calculated. Each of the nine calibration steps is not required, but is advisable to properly scale and un-bias the 'raw' measurements, and each step can be repeated if a human or any other error occurs during such a step.

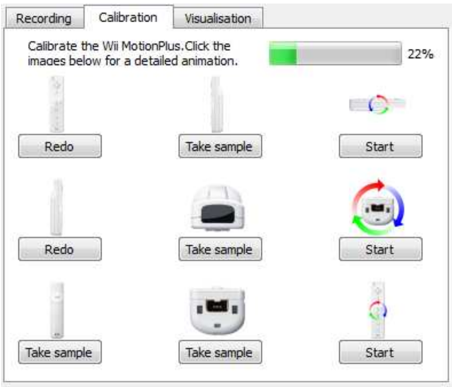

Figure 1 GUI of the calibration tool, showing animations to inform the user on the position and the movements of the Wiimote during calibration.

3. RECORDER TOOL

The Wii MotionPlus toolkit's Qt based [4] graphical interface provides the user with the choice of recording for either a fixed period of time or for the duration of holding the 'B button' on the remote itself. In both cases, the user has the ability to select the parts of the information stream that are of interest to him (see Figure 2). After all states have been gathered, the selected information is saved in either csv or txt format. At the end of the output file, all information on the employed calibration parameters are added.

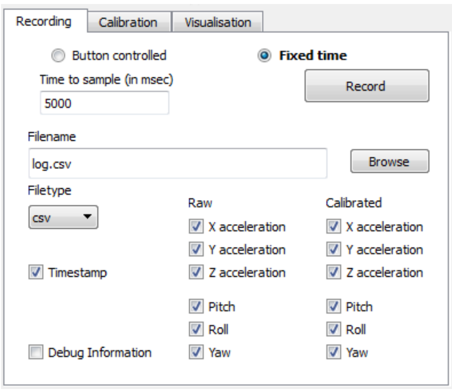

Figure 2 GUI of the recording tool including the options to be set by the user, such as sample time, file name, and the sensor data to be stored.

4. VISUALISATION TOOL

When one is interested in the variation of sensor data over time, an oscilloscope-like representation is one of the best possible solutions. A separate oscilloscope visualization is provided for both sensor types, each displaying three graphs corresponding to the three axes of acceleration, or the three axes of rotation. Sliders for scaling the horizontal time axis, as well as the vertical axis corresponding to acceleration or angular momentum, are provided (see Figure 3).

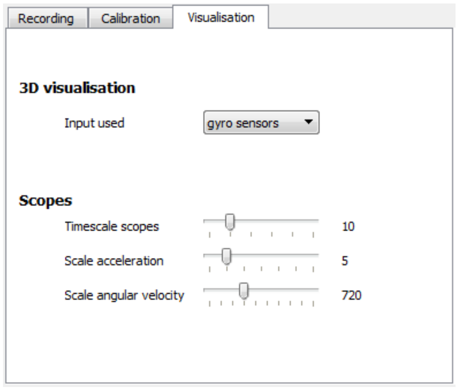

Figure 3 Part of the GUI of the visualization tool, including the sliders for the oscilloscope function.

Additionally, true one-on-one mapping from the real world onto the virtual world is performed by showing a 3D Wii remote model, rotating around its three axes, according to the rotation made by the user. The inputs upon which to base this visualization can be set to use the accelerometers only, the gyro sensors only, or by combining both using a Kalman filter. These options allow the user to experience the possibilities and the limitations of either type of sensor. Accelerometers can only display orientation in a vertical plane, as rotation in a plane perpendicular to the earth's gravitational force cannot be sensed. Moreover, accelerometers also measure true translational acceleration of the Wiimote. As gyro sensors can only measure angular velocity, they cannot provide any information about the initial position of the Wiimote. Therefore, the 'home button' on the Wii controller will function as a reset button to return to the standard position of Wii remote laying on its back. Moreover, even after careful calibration, the slightest measurement error will quickly lead to large deviations, because of the integration of the bias. A common way of combining data from different types of inertial measurement units, is a Kalman filter. The visualization tool includes an implementation of the Kalman filter presented by Luinge and Veltink [5].

5. REFERENCES

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